SAGINAW MACHINE SYSTEMS, INC.

Better Precision for Machine Tools Through Thermal-Error Correction

Machine tools are used in hundreds of thousands of plants and shops to cut and shape metal parts and pieces. The interface between the cutting or shaping tool and the material being worked almost always gets hot. In most cases, a coolant is directed onto the interface area to take away enough heat to allow the job to be performed.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* *

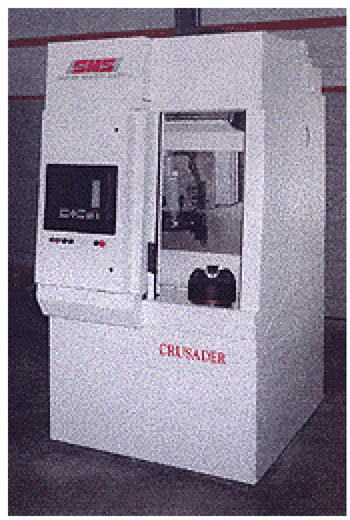
High Heat Degrades Machining Quality

Even with the coolant, the machine tool itself often becomes warm enough to change shape slightly, and the accuracy of the machining operation degrades. The result can be a finished part that fails to meet specifications. What would have become a salable part becomes scrap metal, and some high-precision parts cannot be made at all.

Thermal-Error Compensation

With ATP funding, Saginaw Machine Tools — a small, privately held company founded in 1983 to build precision computer-controlled machine tools for high-volume manufacturing — together with researchers at the University of Michigan, developed a solution to the heat problem. Their technology monitors the temperature gradients in computer numerically controlled (CNC) machine tools and alters the control process dynamically (while the machine is working) to compensate for heat-related changes in the machine tool as the part is being worked. When the new technology is incorporated into machine tools, the result is higher-quality parts.The technology uses a laser system to measure machine geometric and thermal errors and heat sensors to monitor temperatures near the interface between the cutting tool and the metal being worked. A computer program, using a thermal volumetric error model, processes the laser and sensor data and sends corrective instructions to the machine tool in real time, as it shapes the metal. Use of this thermal-error compensation technology enhances the accuracy of CNC machine-tooled products by fourfold to fivefold as measured by spindle drift (shifting of the shaft, in a lathe or other machine tool, that holds the piece being formed), at a commercially viable cost.

Customers manufacturing high-precision parts realize productivity improvements of 10 percent to 30 percent . . .



A new high precision vertical lathe which incorporates the new thermal-error compensation technology, first delivered to customers in 1998.

First Products to Market

At the end of the ATP funding period, additional development work not originally foreseen by the company remained to be done. Saginaw continued to advance the technology and has invested as much of its own funds since the close of the project as the ATP put in at the beginning.

PROJECT HIGHLIGHTS

Project:
To develop an easily adaptable thermal-error correction technology for enhancing the accuracy of computer numerically controlled machine tools.

Duration: 4/15/1991 — 11/16/1993
ATP Number: 90-01-0232

Funding (in thousands):

ATP	$540	84%
Company	100	16%
Total	$640	

Accomplishments:
Saginaw, working closely with researchers at the University of Michigan, accomplished the project's technical goals by developing a generic mathematical model of thermal errors, as well as the sensor and computer-control systems for a thermal-error correction technology. The company also:

- developed several prototype tools incorporating the new technology;

- submitted a prototype, as did seven other manufacturers, for testing by an independent laboratory, which found that the Saginaw machine was the most accurate of the eight machines, with an overall score 50% higher than the next best machine; and

- developed the Accu-System, which incorporates the ATP-funded technology, offered commercially for the first time in a machine tool in early 1998.

Commercialization Status:
Commercial products were introduced to the market in early 1998.

Outlook:
The outlook for this technology is very promising. Saginaw started receiving orders in early 1998 for machine tools that incorporate the new technology. Machine tools that could benefit from the improved accuracy are used in plants and shops throughout the nation. Other tool producers are likely to imitate the technology, which is not expected to receive patent protection. Users of the tools that incorporate the new technology will benefit from a substantial improvement in machine tool accuracy, increasing the overall precision of the pieces produced by the machines.

Composite Performance Score: * *

Number of employees: 120 at project start, 120 at the end of 1997

Company:
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Subcontractor: University of Michigan

Since completing the development work, the company has begun to move its first product, which uses the Accu-System incorporating the ATP technology, into commercialization. By early 1998, Saginaw had developed prototype tools. One prototype was tested by an independent laboratory and pronounced ready for market. Another tool from Saginaw was subjected to a competitive evaluation process by a large tool buyer, in which the Saginaw tool was pitted against tools from seven other suppliers. The results showed that the Saginaw machine with the Accu-System was the most accurate. All in all, 30 characteristics of machine performance were measured, and the Saginaw machine had a weighted average score that was 50 percent higher than the next best machine. On the critical characteristic of spindle drift, the Saginaw machine achieved a two-thirds reduction in drift compared with the next best machine.

By March 1998, Saginaw had received orders from other companies for eight machines priced at more than $200,000 each. Orders for several dozen additional machines of the same type were expected over the next several months.

. . . most machine tools that make high-precision parts are likely to be improved in the long run.

Productivity Improvements

Users of the technology are able to take advantage, at reasonable cost, of a substantial increase in the accuracy of their machine tools, improving the precision of the workpieces the machines produce. Customers manufacturing high-precision parts realize productivity improvements of 10 percent to 30 percent because of reduced requirements for part testing and rework.

The number of potential applications is large. Because the Saginaw equipment is now in use, other manufacturers may imitate the technology. The company has concluded that none of the technology is patentable, and it is likely that competitors will be able to imitate its methods. Consequently, most machine tools that make high-precision parts are likely to be improved in the long run.

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If Saginaw had not received the ATP award, company officials say, it would not have done the project. Being primarily a manufacturing company, it did not have a substantial research and development capability. While working on the ATP project, Saginaw collaborated with the University of Michigan on a subcontractor basis to extend the company's research capabilities. In addition, officials say, having the ATP award helped Saginaw win a subsequent $1 million award from the Defense Advanced Research Projects Agency for a related project.

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